

# **Exhibit R**



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(12) **United States Patent**  
**Poulin**

(10) **Patent No.: US 10,353,811 B2**  
(45) **Date of Patent: \*Jul. 16, 2019**

(54) **SYSTEM FOR DEVELOPING AND TESTING A MOBILE APPLICATION**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(63) Continuation of application No. 14/581,475, filed on Dec. 23, 2014, now Pat. No. 9,971,678, which is a continuation of application No. 13/673,692, filed on Nov. 9, 2012, now Pat. No. 8,924,192, which is a continuation of application No. 12/759,543, filed on Apr. 13, 2010, now Pat. No. 8,332,203, which is a (Continued)

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**G06F 9/445** (2018.01)  
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**G06F 17/50** (2006.01)  
**G06Q 20/14** (2012.01)

(52) **U.S. Cl.**

CPC ..... **G06F 11/3688** (2013.01); **G06F 11/3457** (2013.01); **G06F 17/5009** (2013.01); **G06Q 20/145** (2013.01); **G06F 2201/86** (2013.01)

(58) **Field of Classification Search**

CPC .. G06F 11/3688; G06F 9/445; G06F 11/3457; G06Q 20/145  
USPC ..... 703/22, 23; 455/423; 709/223  
See application file for complete search history.

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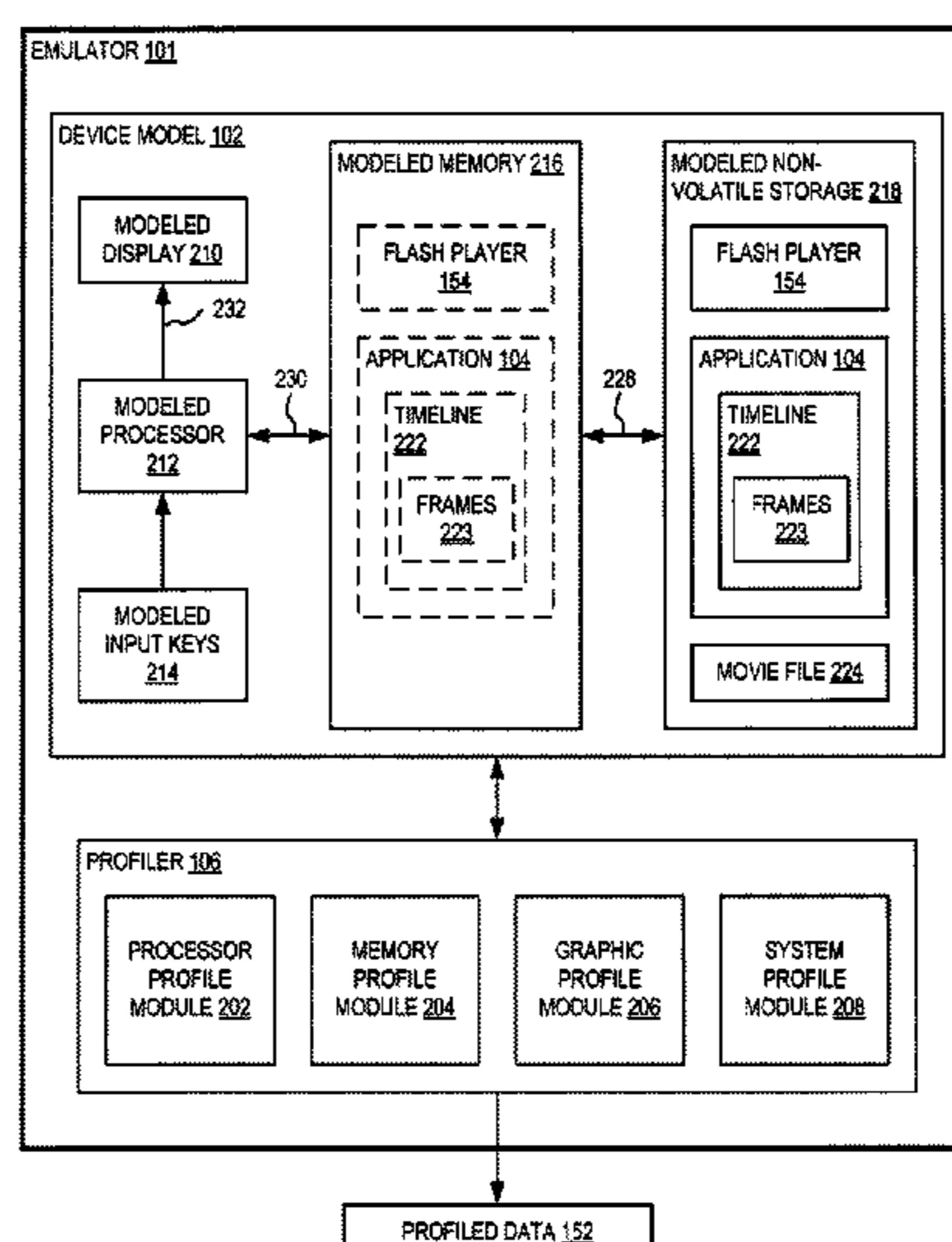
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(57) **ABSTRACT**

A system and methods to emulate an application executing in real time in a mobile device. The mobile device is emulated in real time using a model running on a processor extrinsic to the mobile device. The model is based on characteristics indicative of performance of the mobile device. The application is executed in real time within the model and the application executing in the model is monitored to determine resource utilization information by the application for the mobile device. The resource utilization information for the mobile device is displayed.

**30 Claims, 14 Drawing Sheets**



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**Related U.S. Application Data**

continuation of application No. 11/449,958, filed on Jun. 9, 2006, now Pat. No. 7,813,910.

- (60) Provisional application No. 60/689,101, filed on Jun. 10, 2005.

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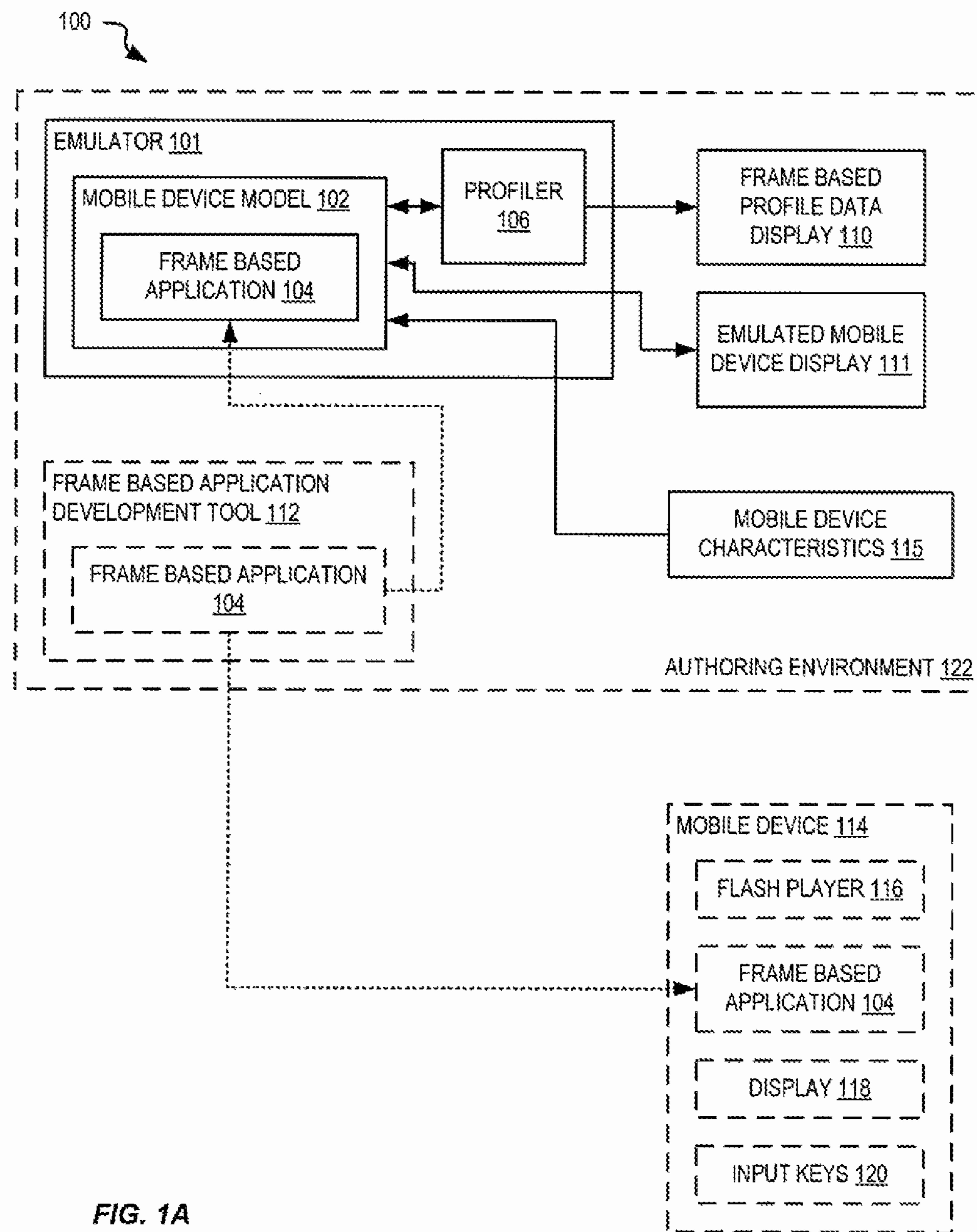


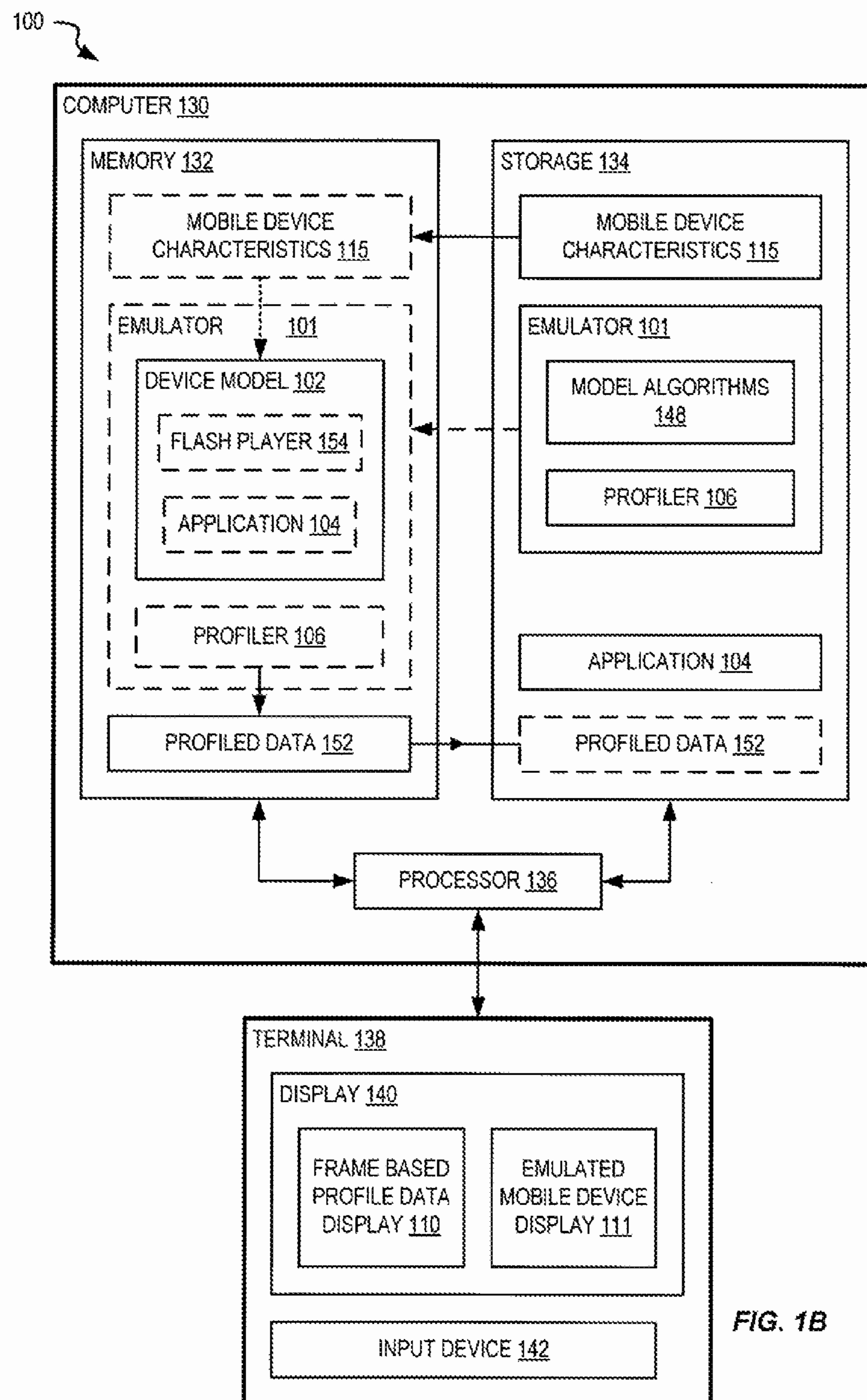
FIG. 1A

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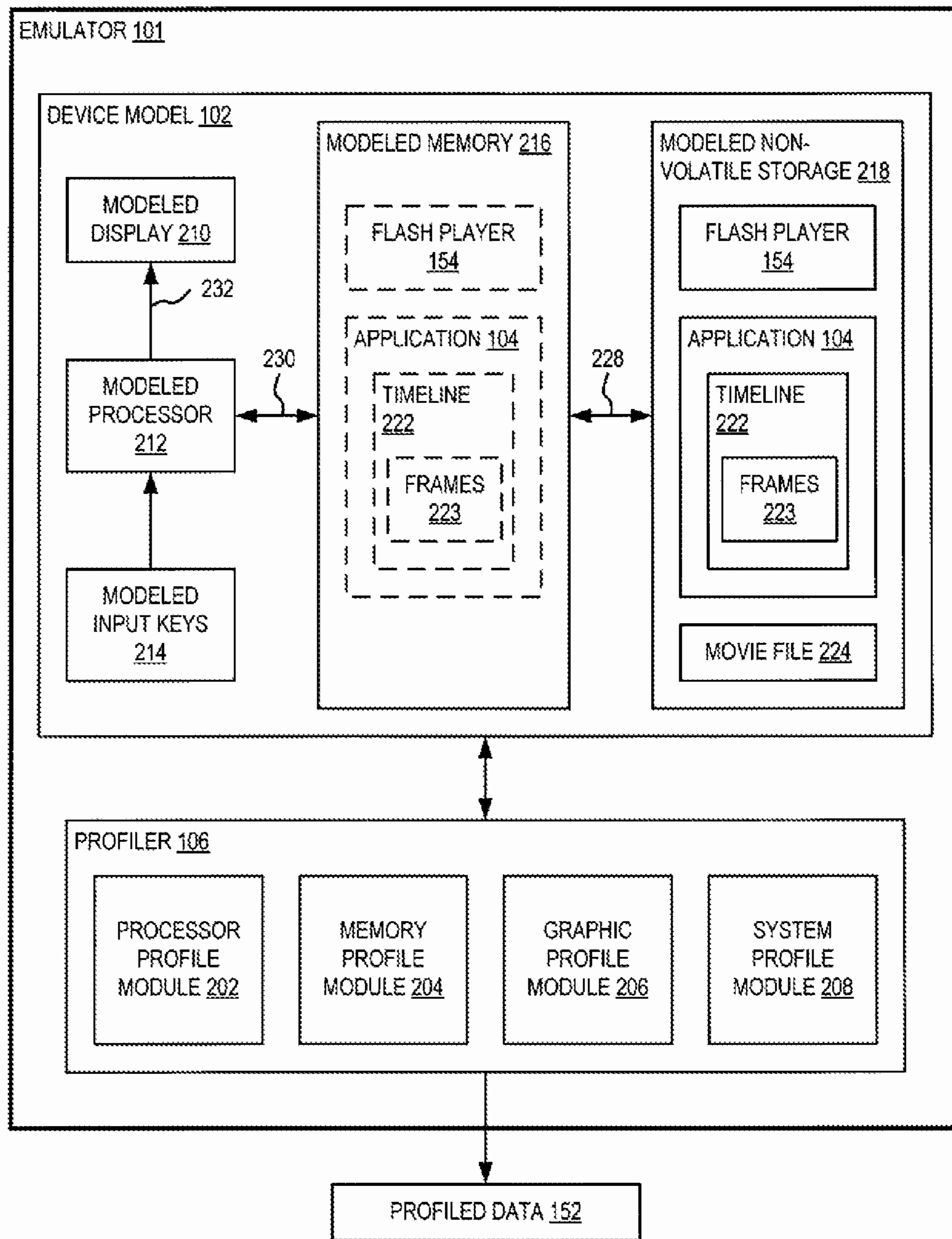


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**FIG. 2**

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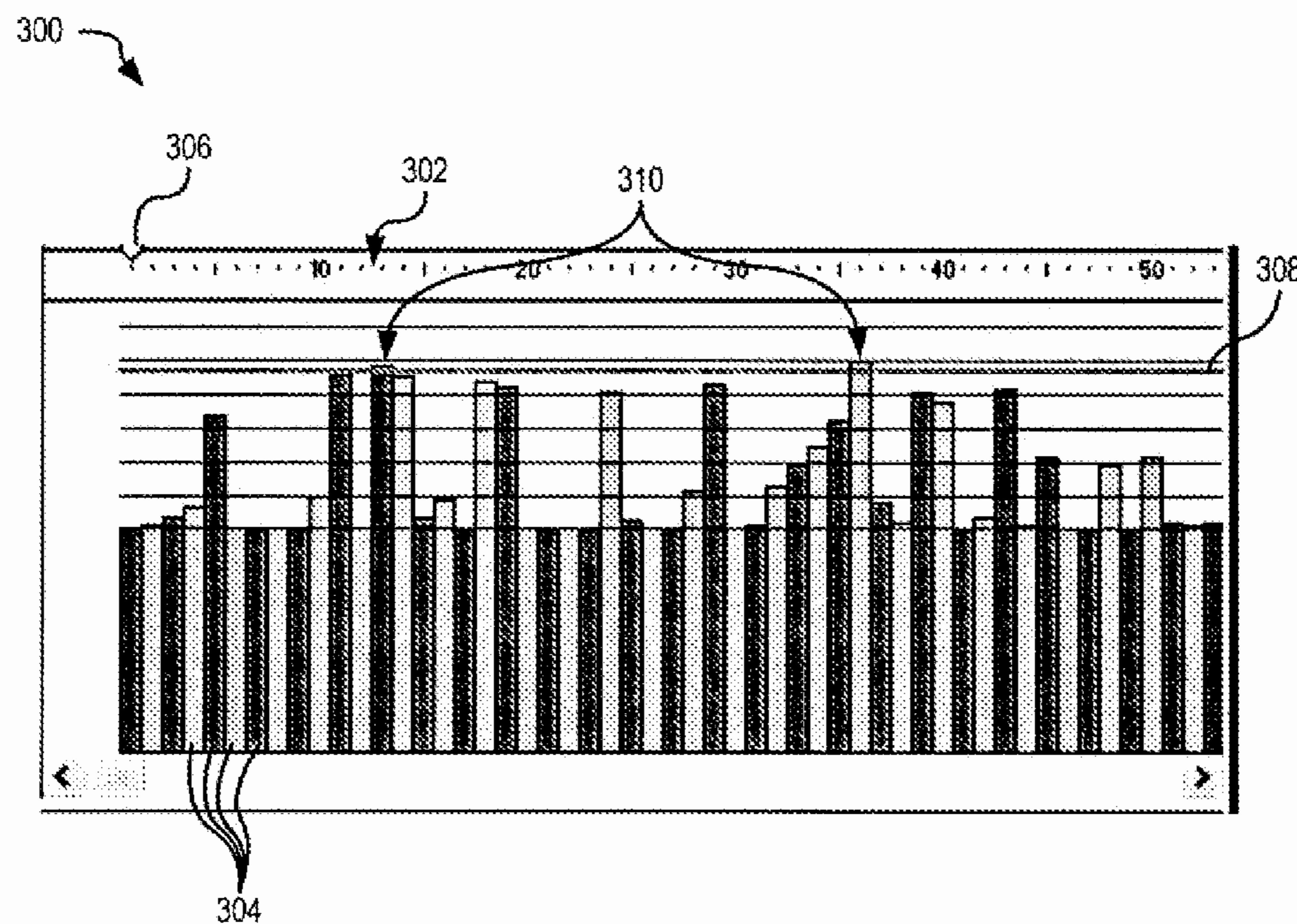


FIG. 3

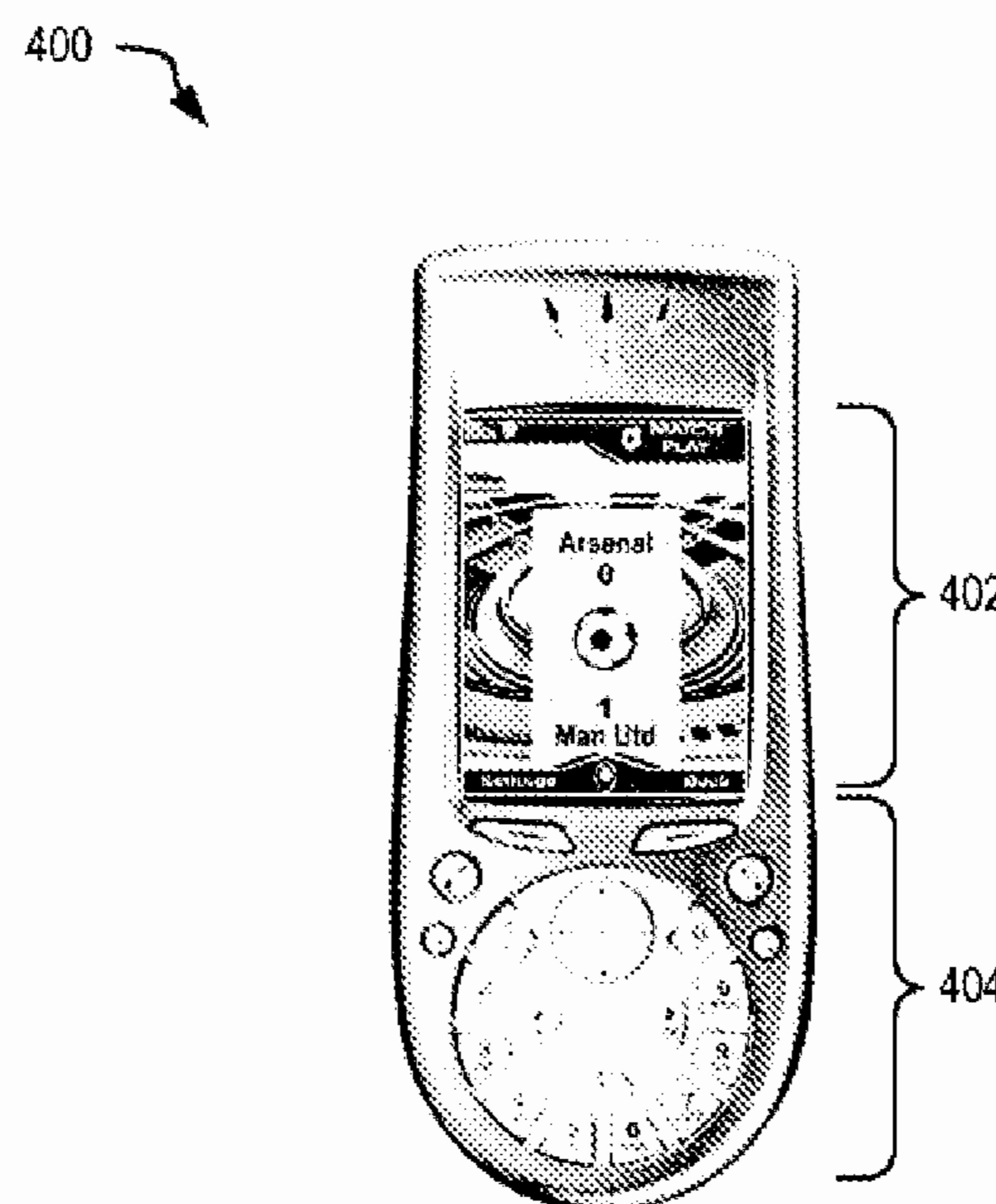


FIG. 4

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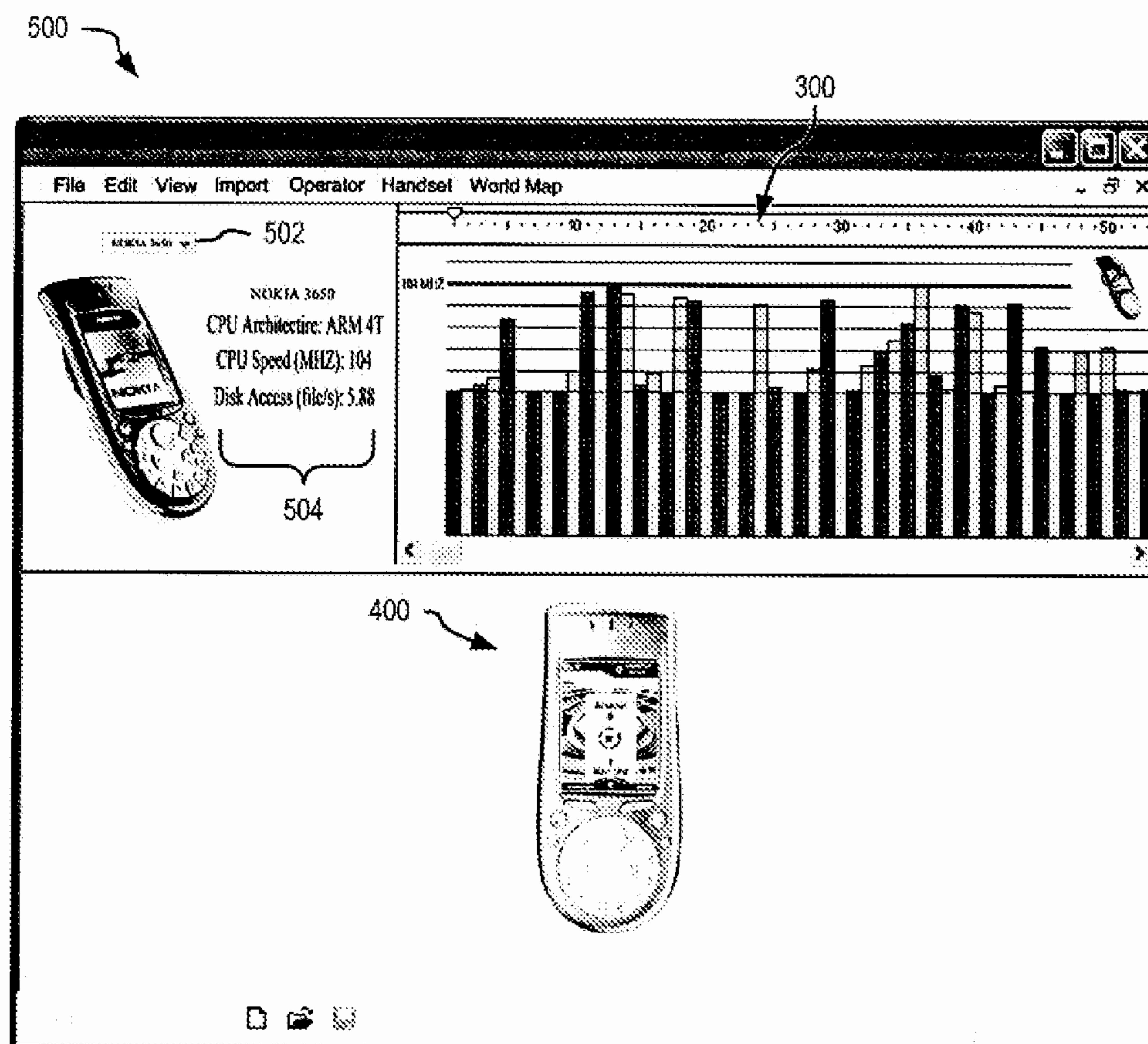


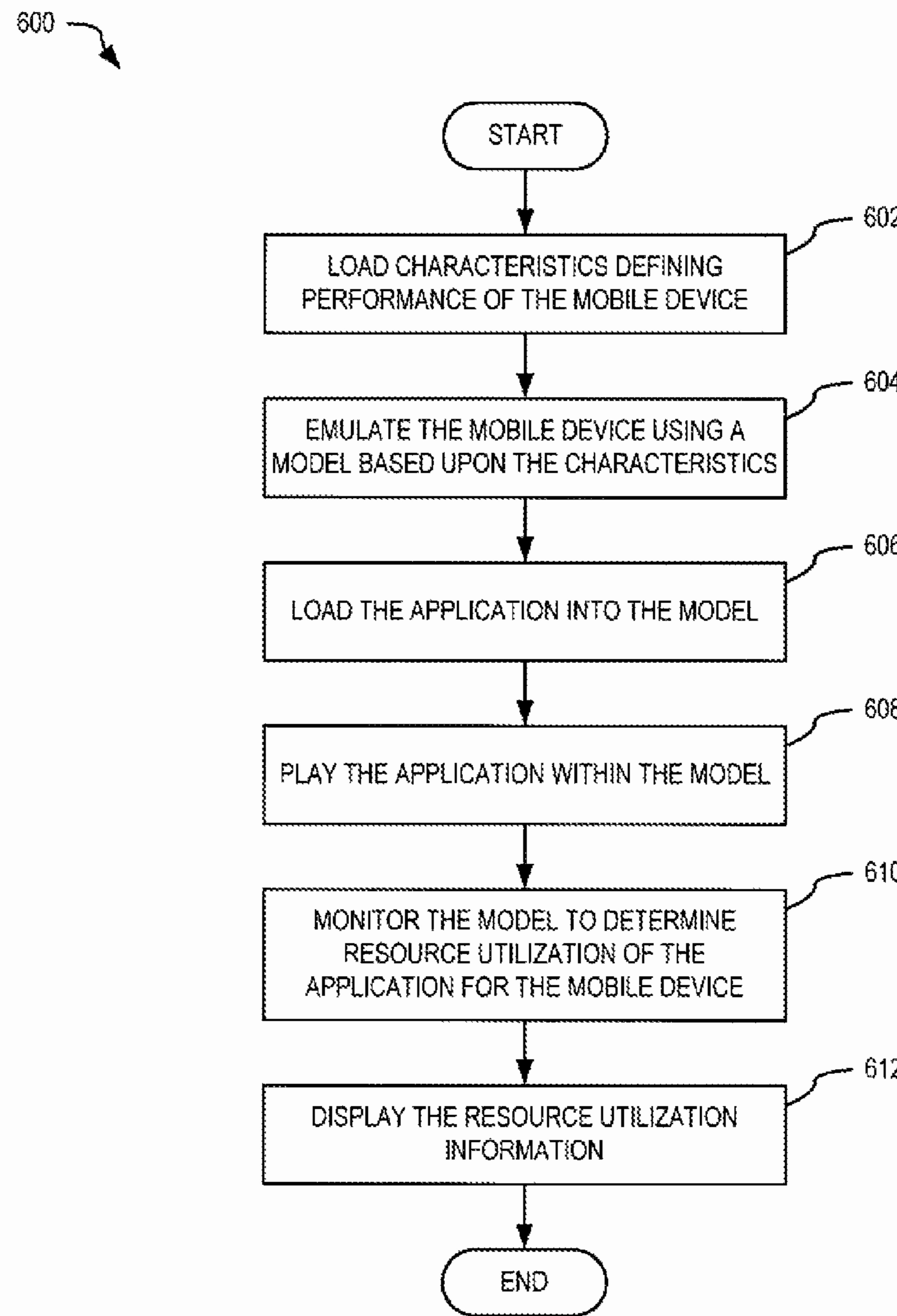
FIG. 5

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**FIG. 6**

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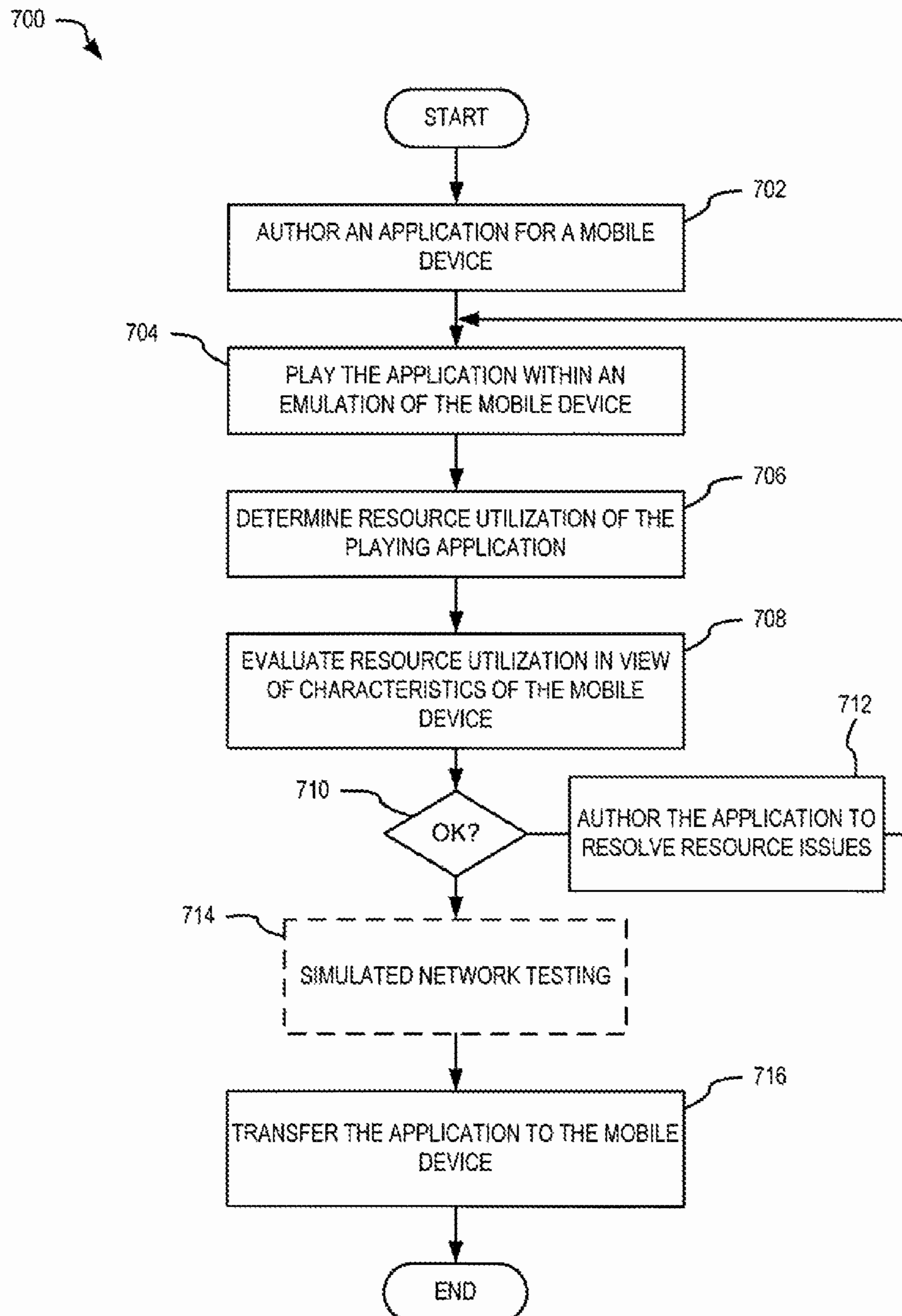


FIG. 7

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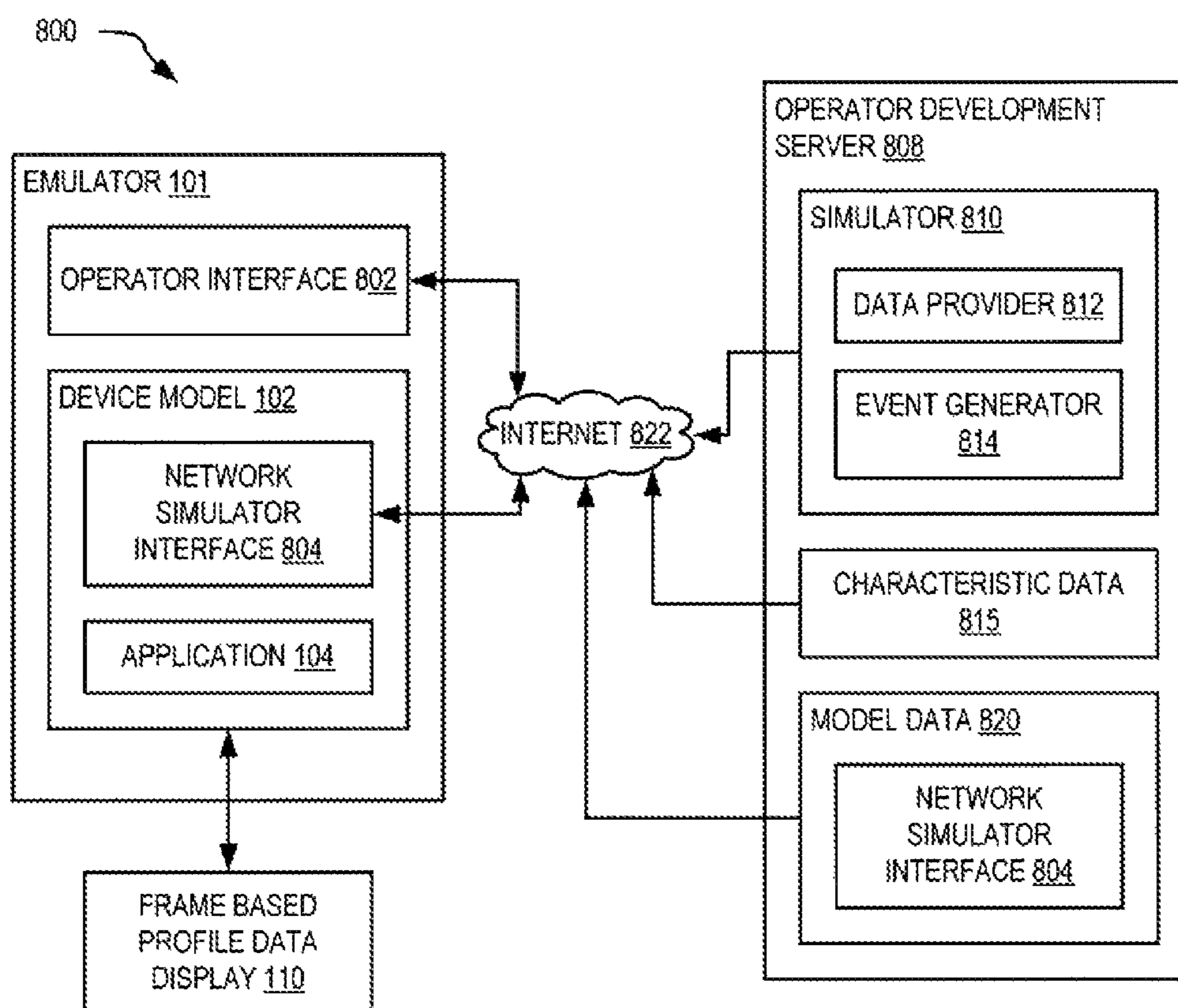


FIG. 8

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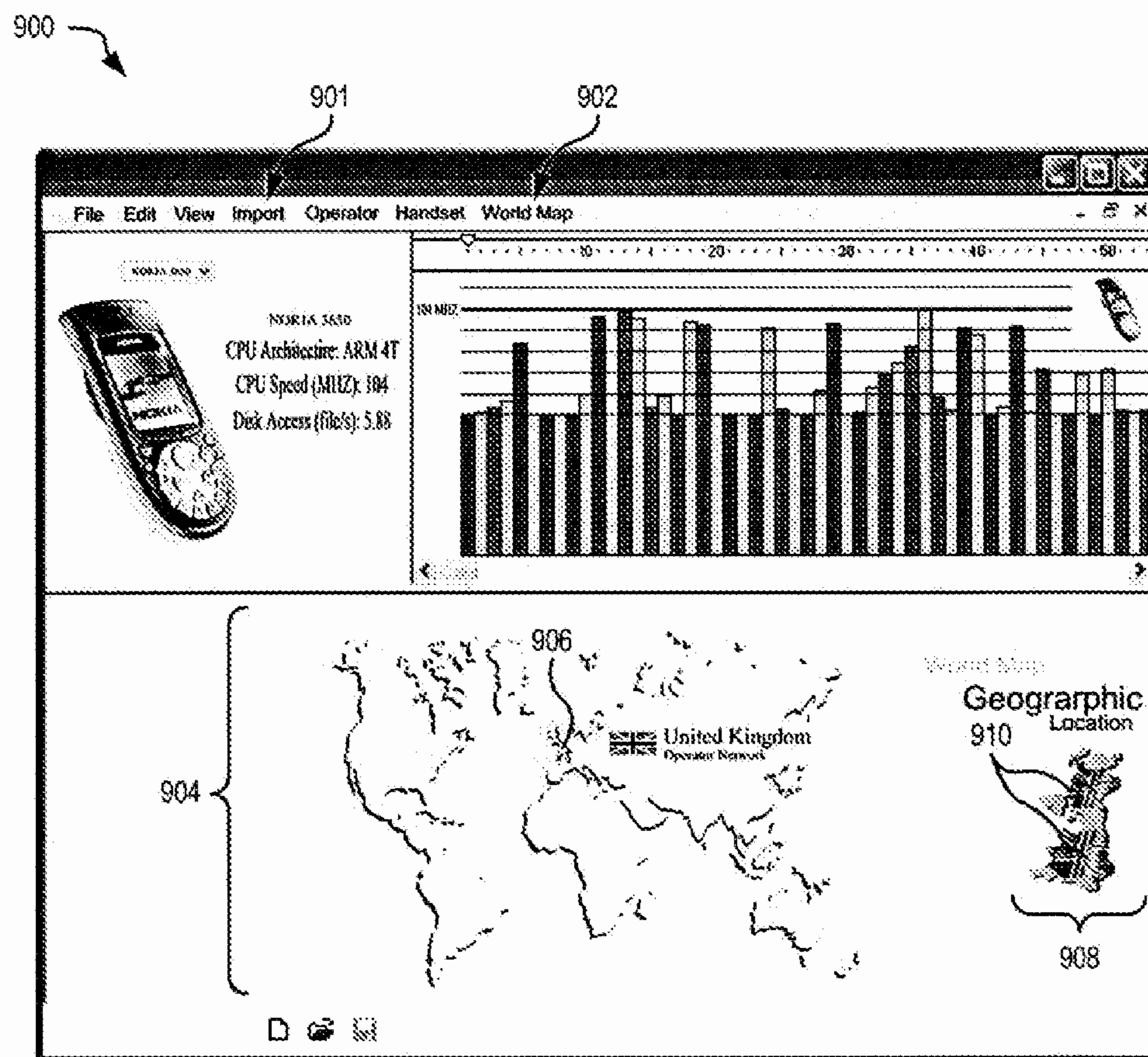


FIG. 9

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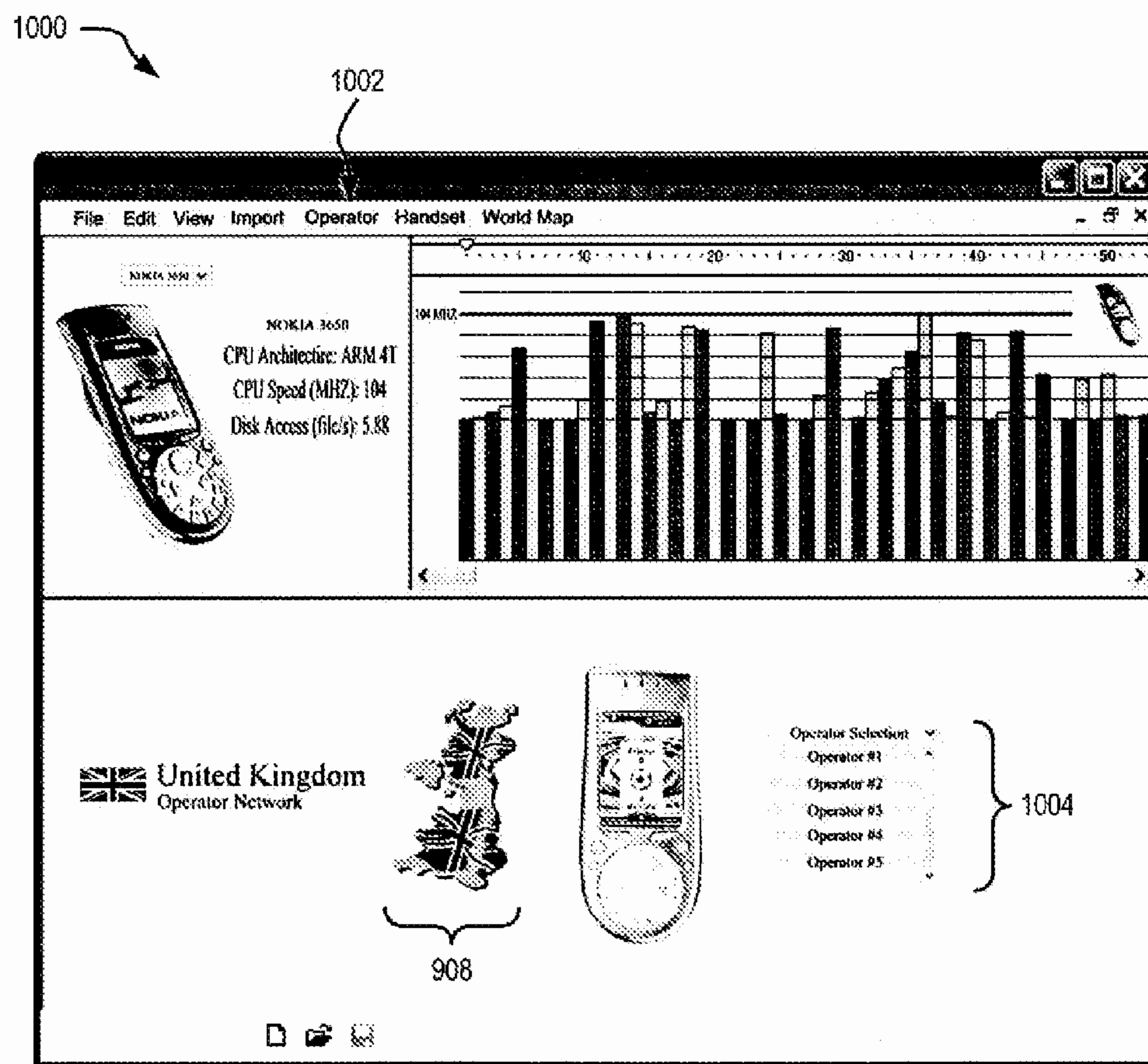


FIG. 10

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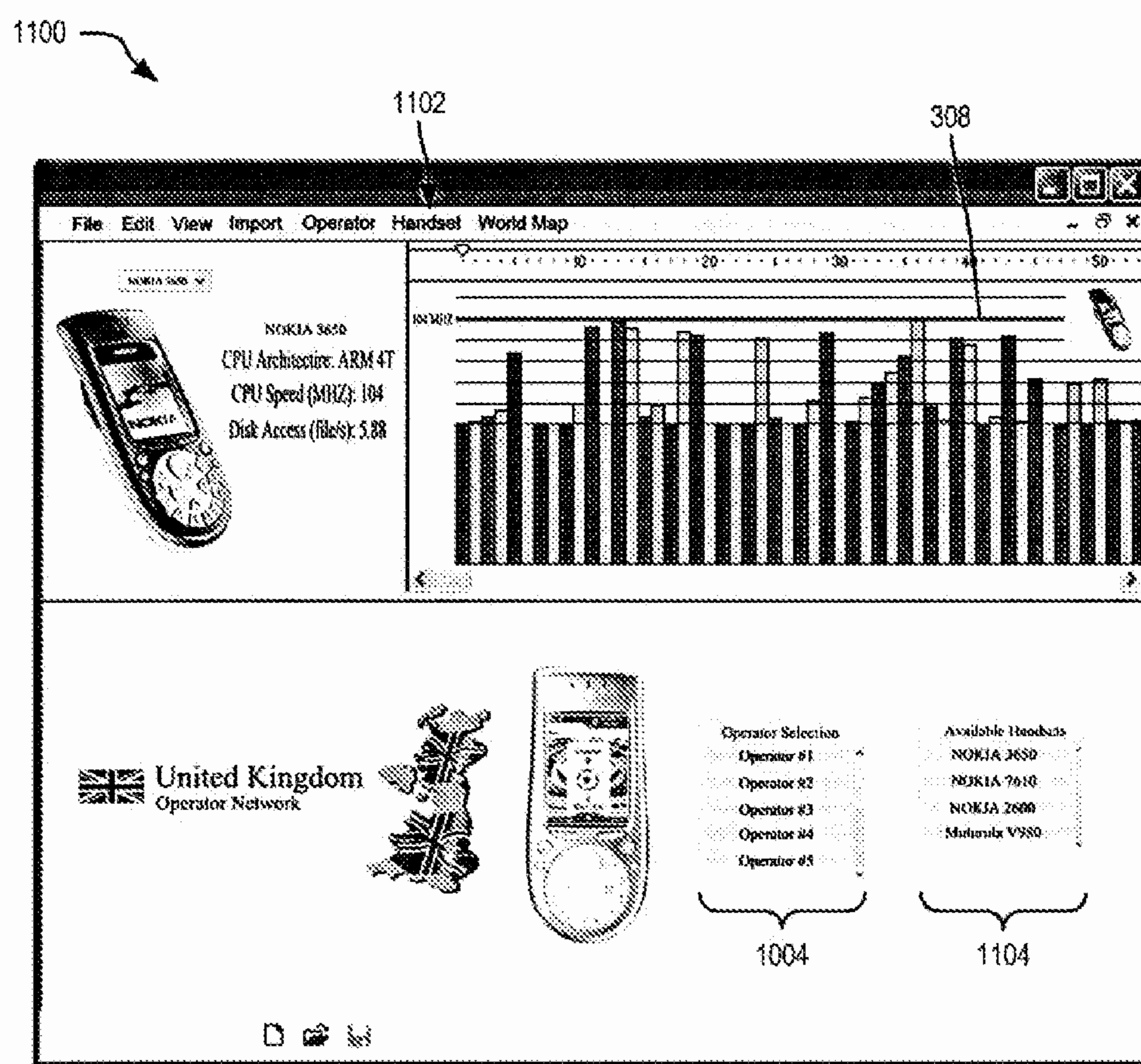


FIG. 11

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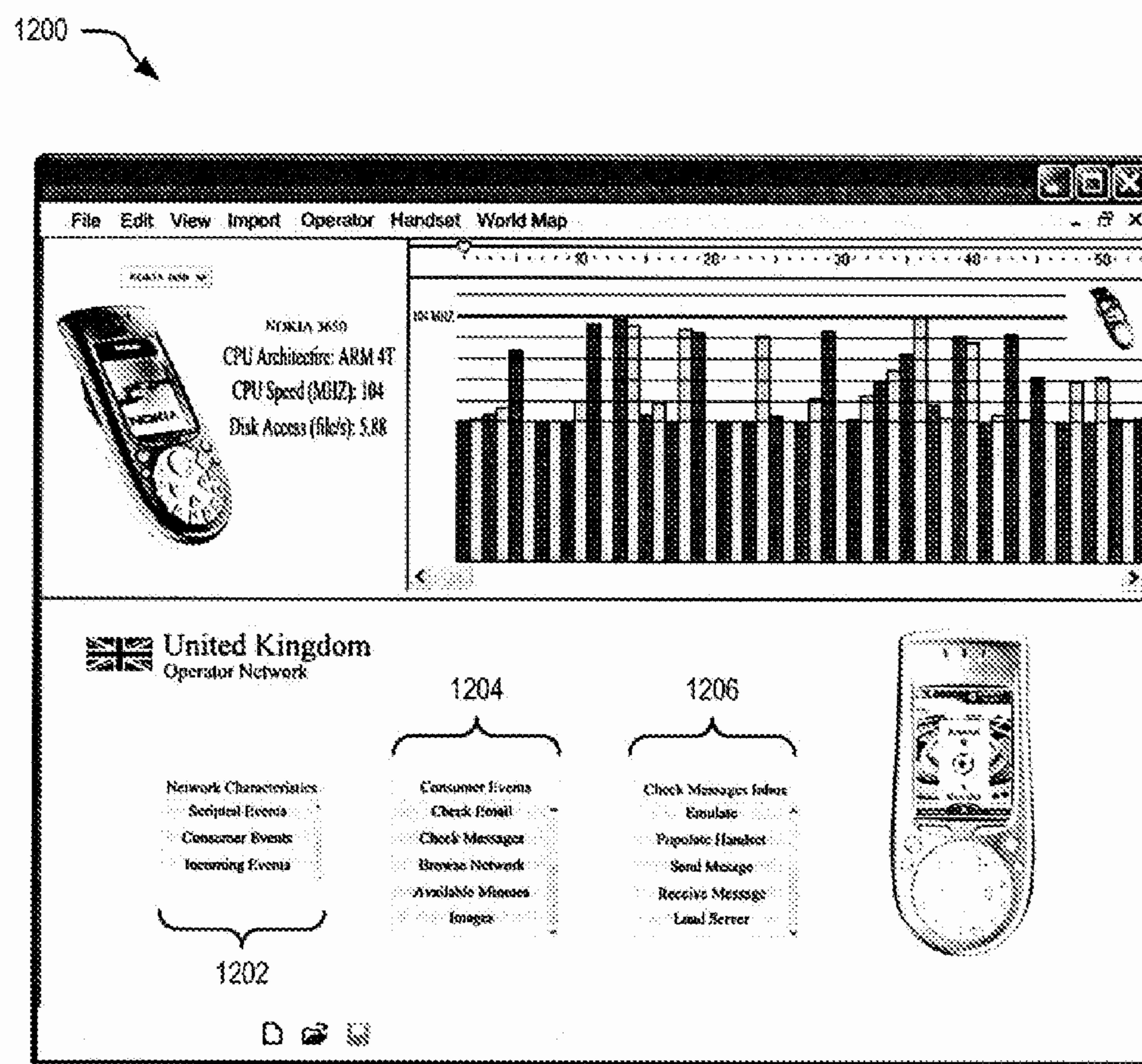


FIG. 12

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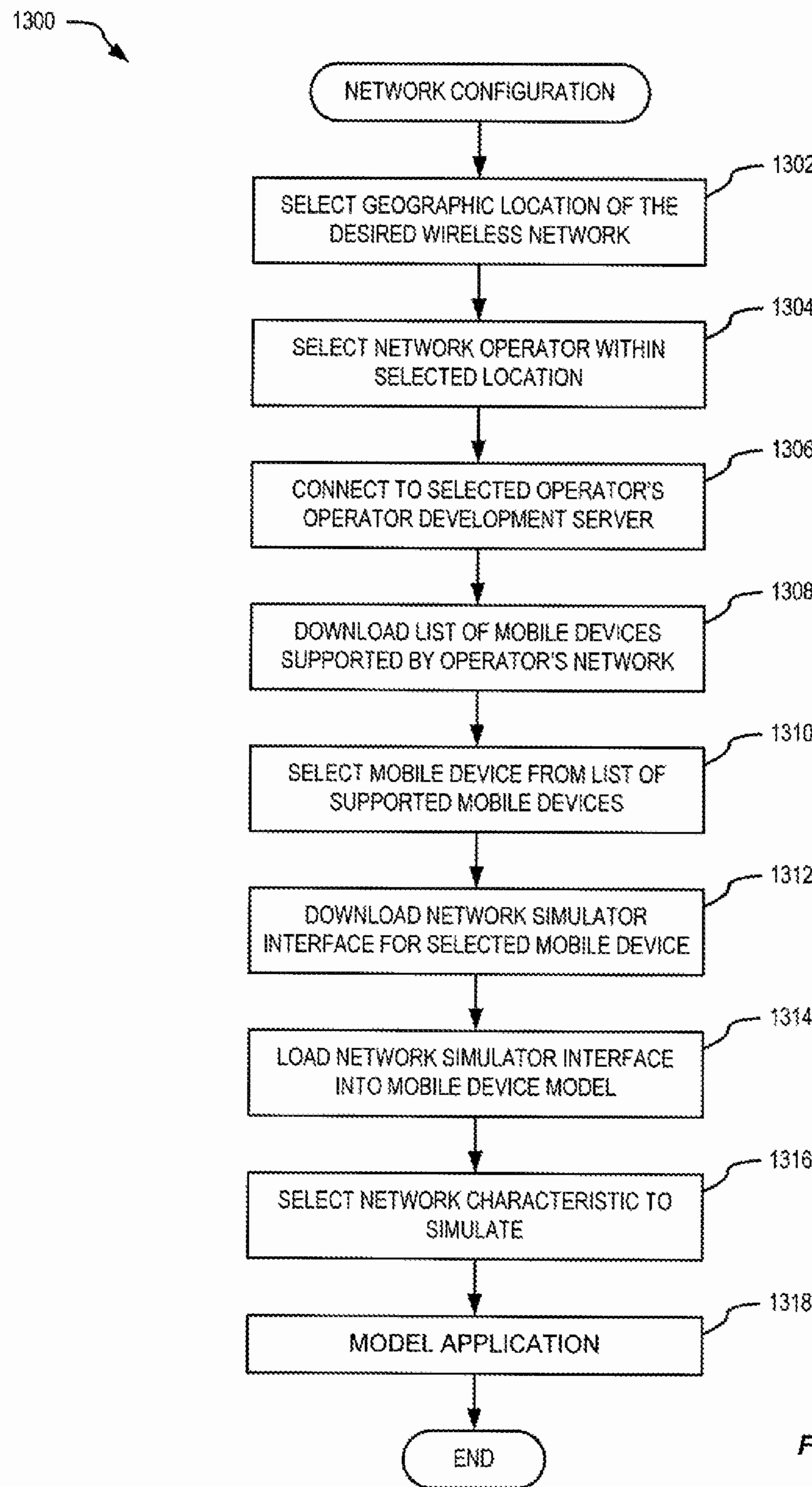


FIG. 13

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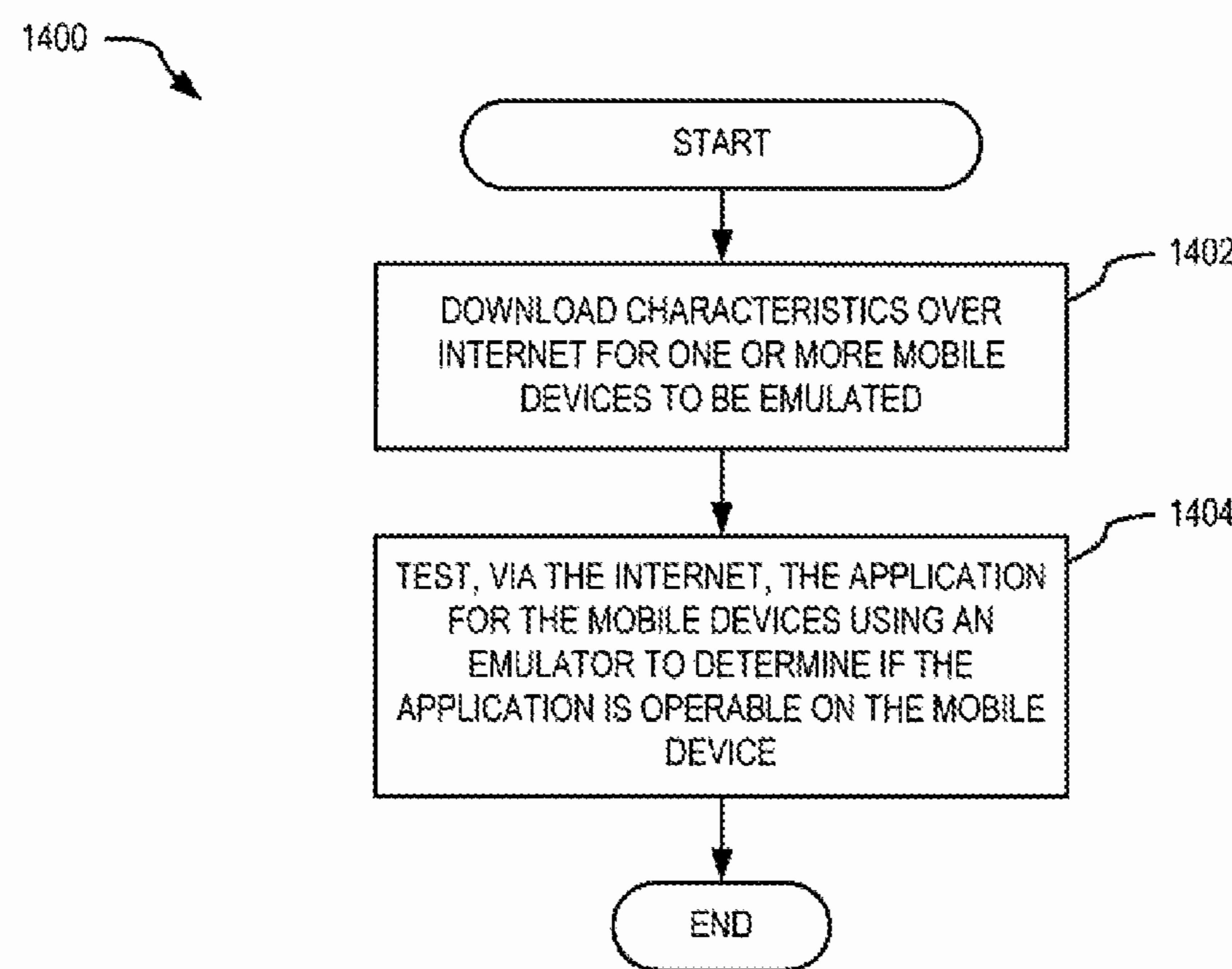


FIG. 14

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**SYSTEM FOR DEVELOPING AND TESTING  
A MOBILE APPLICATION****CROSS REFERENCE TO RELATED  
APPLICATIONS**

This application is a continuation of pending U.S. patent application Ser. No. 14/581,475, filed Dec. 23, 2014, which is a continuation of U.S. patent application Ser. No. 13/673,692, filed Nov. 9, 2012, and issued as U.S. Pat. No. 8,924,192, on Dec. 30, 2014, which is a continuation of U.S. patent application Ser. No. 12/759,543, filed Apr. 13, 2010, and issued as U.S. Pat. No. 8,332,203, on Dec. 11, 2012, which is a continuation of U.S. patent application Ser. No. 11/449,958, filed Jun. 9, 2006, and issued as U.S. Pat. No. 7,813,910, on Oct. 12, 2010, which application claims priority to U.S. Patent Application No. 60/689,101 filed Jun. 10, 2005. These applications and patent are incorporated herein by reference, in their entirety, for any purpose.

**BACKGROUND**

It is estimated that the mobile market is evolving at five times the speed of the eCommerce market. It is estimated that nearly 700 million new mobile devices will be shipped in 2005, with a new handset model being launched every other day. This rapid mobile device development requires that applications designed to run on these mobile devices also sustain rapid development. Development systems targeted at one mobile device may become obsolete and possibly of little value to the developer at the time it is shipped as well as development life cycles.

Many new mobile devices include a display management engine called a Flash Player; one example of a Flash Player suitable for mobile devices is FlashLite, developed by Macromedia. The Flash Player provides a common application platform for playing applications on the mobile devices and allows developers to develop applications that may be played on multiple mobile devices that include the Flash Player. Applications for mobile devices are typically developed on a personal computer (PC) or workstation and target one or more types of mobile device that include a Flash Player. These applications require real-time testing of the application on all applicable mobile devices. Although a Flash Player application may operate correctly on one mobile device model, it may crash when playing on a different mobile device model. For example, a NOKIA 6600 has a 16% reduction in ARM CPU speed and available memory resources compared to a NOKIA 7610, thus an application that plays correctly on the NOKIA 7610 may not play correctly on the NOKIA 6600 due to this drop in inherent resources.

Development packages (e.g., FlashMX by Macromedia) are available to run on a PC and allow development of Flash Player applications for one or more mobile devices. However, although these development packages may simulate operation of the application playing on the targeted mobile device, they do not determine if the application will play correctly on the targeted mobile device based upon resource usage. Currently, the only way to determine if an application plays on a particular mobile device is to transfer the application to the device and play it. During development of an application for a mobile device, an application author may transfer and play the application hundreds of times (development life cycles) on the targeted mobile device before identifying and correcting all system resource problems within the application. Where an application is targeted to

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play on many types of mobile device, it must be transferred and tested on a mobile device representative of each targeted mobile device type. This transferring and testing process is time-consuming and therefore costly for the application author.

Further, having accessibility to all available mobile devices in targeted geographical markets worldwide as well as real-time interaction with network Operators to measure and emulate network characteristics within each market is presently not possible.

**SUMMARY OF THE INVENTION**

In one embodiment, a method emulates and profiles an application to play on a mobile device that includes a Flash Player. Characteristics defining performance of the mobile device are loaded. The mobile device is emulated using a model based upon the characteristics. The application is played and monitored within the model to determine resource utilization of the application for the mobile device.

In another embodiment, a method authors, emulates and profiles an application to play on a mobile device that includes a Flash Player. The application is authored using an application development tool and the mobile device is emulated using a model based upon the characteristics. The application is played within the model and the model is monitored to determine resource utilization of the application for the selected mobile device.

In another embodiment, a method authors an application to play on a mobile device that includes a Flash Player. The application is authored using an application development tool. Resource utilization of the application for the mobile device is estimated. The steps of authoring and estimating are repeated until the resource utilization is less than or equal to the resources available on the mobile device.

In another embodiment, a software product has instructions, stored on computer-readable media, wherein the instructions, when executed by a computer, perform steps emulating and profiling an application to play on a mobile device that includes a Flash Player, including: instruction for loading characteristics defining performance of the mobile device; instruction for emulating the mobile device using a model based upon the characteristics; instruction for playing the application within the model; and instruction for monitoring the application playing in the model to determine resource utilization of the application for the mobile device.

In another embodiment, an emulator profiles an application of a mobile device that includes a Flash Player, including: means for generating a model of the mobile device based upon mobile device characteristics, and means for playing the application within the model to determine resource utilization of the application when played by the mobile device.

In another embodiment, a method determines whether an application of a mobile device is operable. Characteristics are downloaded over Internet for one or more mobile devices to be emulated and the application for the mobile devices is tested, via the Internet, using an emulator to determine if the application is operable on the mobile device.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1A shows one exemplary embodiment of a system for emulating, authoring and visually profiling an application playing on a mobile device that includes a Flash Player.

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FIG. 1B shows one exemplary embodiment of the system of FIG. 1A within a computer.

FIG. 2 is a block diagram illustrating detail of an emulator of the system of FIGS. 1A and 1B.

FIG. 3 is a display showing one exemplary frame based profile graph.

FIG. 4 is a display showing the modeled mobile device of FIGS. 1A and 1B.

FIG. 5 shows one exemplary window that includes the display of FIG. 3, the display of FIG. 4 and an exemplary user interface.

FIG. 6 is a flowchart illustrating a method for modeling and profiling an application to play on a mobile device that includes a Flash Player.

FIG. 7 is a flowchart illustrating one method for authoring, emulating and profiling an application to play on a mobile device that includes a Flash Player.

FIG. 8 is a block diagram illustrating the emulator of FIG. 1 interacting with an operator development server via the Internet for simulating playing of the application within a mobile device connected to a wireless network.

FIGS. 9, 10, 11 and 12 show exemplary user interface screens for interacting with the emulator of FIG. 1 to configure and test operation of the application within the model of the mobile device when connected to a wireless network.

FIG. 13 is a flowchart illustrating one exemplary method for configuring network simulation.

FIG. 14 is a flowchart illustrating one method for determining whether an application of a mobile device is operable.

## DETAILED DESCRIPTION

### The Personalization of Mobile Commerce.

A perfect storm is emerging in one of the largest consumer markets to date—mobile commerce. Industry analysts estimate that the mobile commerce market will reach an unprecedented 500 billion dollars per annum by 2008 worldwide. In 2003, the ARPU (Average Revenue Per User) in mobile commerce was \$72 dollars. In 2008 it is predicted to reach an average of \$332 dollars per user. What will drive the ARPU to reach 4-5 times what it is today? More specifically, as this new global market emerges, which platform(s) will sustain this unprecedented market opportunity?

Early frontrunners like Java, .NET and BREW have taken great strides in the early/formative years, the likes of SurfKitchen, Action Engine, MFORMA and others taking SMS, MMS and mobile gaming to exciting consumer levels. However, with a market primarily based on the Java and J2ME platform, mobile content and entertainment revenues achieved less than 3% of the total mobile service revenue and less than 19% of non-voice revenue.

Is this a failure? Based on current market projections and a weighted ARPU, total consumer spending on mobile content will only achieve approximately 72Bn by 2008. With the inherent runtime limitations of these current languages, consumer uptake of mobile content will reach approximately 1/7 or 14% of the total projected levels by 2008. Therefore, either Java and the early frontrunners will substantially evolve to become a more consumer-adapted platform to meet an unprecedented market need, or a new platform will emerge to drive mobile commerce to projected levels.

### Consumers Will Lead Mobility the Leaders Will Follow.

‘Software for the People’ is a paradigm shift in client side personalization and mobile architecture. Called

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Active2Play™, this new platform places the personalization of content directly into the hands of the consumer on the client side, similar to what Windows® achieved for the PC. What Symbian is for the handset, Active2Play™ is for the consumer, a personalized windows environment allowing the first customizable application environment for the consumer. To this end, ‘Software for the People’ is built upon three personalized mobile platforms: Active2Play™ Consumer, Active2Play™ UI and Active2Play™ Marketplace.

Active2Play™ Consumer allows the end user the ability to personalize their content operating experience Over-the-Air, delivering an unparalleled platform of client side consumer personalization. From this architecture Kiwi has developed three Consumer Branded platforms: VASports™ (a personalized Over-the-Air consumer sport line); ImageVu™ (a personalized Over-the-Air photo imaging line); and CouponVu™ (A personalized Over-the-Air corporate branding and one-to-one marketing line).

Alongside of the Active2Play™ Consumer platform, Kiwi offers an industry first Flash Lite end-to-end service platform called Active2Play™ UI, enabling realtime branding and personalization of the mobile user interface. Unlike the J2ME platform, Active2Play™ UI dramatically reduces Server Crosstalk™ (a client side architecture), and can be managed and updated Over-the-Air by the consumer, operator and handset maker providing realtime personalization and brand marketing of the handset user Interface.

Active2Play™ Marketplace is an Open Application Marketplace™ for the aggregation and distribution of Flash Lite content, the third and final piece in the Flash Lite ecosystem. From server content distribution, to live variable billing and provisioning, Active2Play™ Marketplace provides an open and accessible platform for the Flash lite developer community to rapidly deploy Flash Lite content.

### Kiwi Revenue Model.

Kiwi estimates that its Flash Lite and Active2Pay™ platform revenues will come from four primary models: (1) Mass-market per handset license fees for embedded applications with handset makers; (2) Mass-market per subscriber license fees for revenue sharing applications with operators; (3) Mass-market per handset license fees for personalized UI’s and brand marketing; and (4) Active2Play™ Marketplace, content aggregation and distribution services as the Flash Lite developer community reaches a critical mass.

With the ability to achieve commerce anywhere at any time, Mobile Commerce presents a unique and global platform for handset makers, operators and consumers alike. “Globally, there were 94.9 million mCommerce users at the end of [2003], and this is predicted to grow to 1.67 billion users by 2008. Meanwhile over the same period revenues from mCommerce will grow globally from US\$6.86 billion in 2003 to over US \$554.37 billion. Telecom Trends International (TTI) Apr. 20, 2004.

As the ecommerce market moves beyond the personal computer to embrace the ‘edge’ or wireless community via the cell phone, companies are aggressively moving to capitalize on a new and emerging 500 billion dollar mCommerce market. With the economic potential of 1.67 billion users by 2008 connecting to the Internet anytime, anywhere to view or buy anything they want via their mobile device, a new breed of company will emerge with the ability to rethink, redesign and re-engineer its architecture to adapt to the ‘client side’ specifics of mCommerce. The convenience of ‘point of sale’ anywhere-you-go will mark an unprecedented cultural shift in consumer buying patterns within international markets.

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FIG. 1A shows one exemplary embodiment of a system 100 for emulating and profiling a frame based application 104 playing on a mobile device 114 that includes a Flash Player 116. System 100 is shown with an emulator 101, a profiler 106 and a display 110. Emulator 101 generates a mobile device model 102, based upon mobile device characteristics 115 of mobile device 114. Model 102 emulates mobile device 114 to play frame based application 104 and may, for example, generate an emulated mobile device display 111 that represents mobile device 114. Emulated mobile device display 111 may be interactive to allow a user to interact (in a manner similar to interacting with device 114) with application 104 while playing within model 102.

Profiler 106 monitors playing of frame based application 104 within model 102 to estimate resource usage of application 104 and generates a frame based profile data display 110. Frame based profile data display 110 may allow a user of system 100 to identify areas within application 104 that would exceed resources of mobile device 114.

Application 104 may be developed using a frame based application development tool 112 (indicated in dashed outline). Frame based application development tool 112 may, for example, represent Flash MX or Studio 8 from Macromedia (now Adobe Systems). Once the user of system 100 has verified that application 104 does not exceed resources of mobile device 114, development tool 112 may be instructed to publish application 104 to device 114, as shown.

In one example of operation, development tool 112 is used to develop frame based application 104. Application 104 is transferred to emulator 101 for playing within mobile device model 102 to estimate resource usage of application 104 when played on mobile device 114. Upon playing application 104 within model 102, emulator 101 utilizes profiler 106 to determine resource utilization of application 104 based upon mobile device characteristics 115.

In one embodiment, emulator 101 is integrated with flash development tool 112 to form an authoring environment 122 that facilitates development and testing of application 104 without the need to continually load application 104 into mobile device 114.

In another embodiment, emulator 101 is an add-in module that may be configured to operate within flash development tool 112.

Mobile device 114 is shown with Flash Player 116, display 118 and input keys 120. In one embodiment, Flash Player 116 is FlashLite™ from Macromedia™ (Adobe Inc.). Mobile device 114 may, for example, represent one of: a cell phone, a personal digital assistant (PDA), an interactive home appliances and other such devices. In one example, display 118 represents a color liquid crystal display (LCD) device for displaying text and images to a user of mobile device 114 and input keys 120 represent buttons that allow the user to interact with mobile device 114.

FIG. 1B shows one exemplary embodiment of system 100 within a computer 130. Computer 130 includes memory 132, storage 134 and a processor 136. Memory 132 is for example random access memory (RAM) and storage 134 is for example a disk drive or other non-volatile storage media.

Storage 134 is shown with emulator 101, mobile device characteristics 115 and application 104. Storage 134 may also include development tool 112, if desired, for developing application 104. Emulator 101 includes model algorithms 148 and profiler 106. Model algorithms 148 represent one or more algorithms that operate to generate mobile device model 102 to emulate mobile device 114 while executing

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application 104. Specifically, model algorithms 148 define operation of mobile device 114 based upon mobile device characteristics 115.

TABLE 1

Mobile Device Characteristics	
Parameter	Value
Name	NOKIA 3650
Processor	ARM 4T
Processor Speed	104 MHz
Storage Access Speed	5.88 files/second
RAM Size	256 MB
Storage Size	512 MB
Display Width	256
Display Height	394
Pixel Depth	24
Processor Availability	60%
RAM Availability	60%
Storage Availability	40%

Table 1 Mobile Device Characteristics shows exemplary characteristics that may be used to specify performance of model 102 to emulate mobile device 114. For example, in Table 1, the characteristics have the following meaning: ‘Processor’ specifies the type of the processor in mobile device 114; ‘Processor Speed’ specifies the clocked speed of the processor within device 114; ‘Storage Access Speed’ specifies the rate at which data can be moved from storage to memory and/or screen within device 114; ‘RAM Size’ specifies the size of the RAM in mobile device 114; ‘Storage Size’ specifies the size of the non-volatile memory in mobile device 114; ‘Display Width’ specifies the number horizontal pixels on display 118 of device 114; ‘Display Height’ specifies the number of vertical pixels of display 118; ‘Pixel Depth’ specifies the number of bits per pixel (e.g., the color depth) of display 118; ‘Processor Availability’ specifies the percentage of processing resource available for use by applications (e.g., where mobile device 114 represents a cell phone, the phone has to maintain ‘phone’ operations while running any applications, thus there may only be a portion of the maximum processing resource available to applications); ‘RAM Availability’ specifies the percentage of RAM available to applications; and ‘Storage Availability’ specifies the percentage of non-volatile storage space available to applications.

Table 1 may be represented as a data structure (e.g., shown as mobile device characteristics 115 within storage 134) and may be stored in a file (not shown) or a database (not shown) within storage 134, or stored remotely. System 100 may include mobile device characteristics (e.g., mobile device characteristics 115) for multiple devices (e.g., device 114). For example, characteristics 115 may be included for each mobile device type targeted by application 104. A user of system 100 may then select one or more target mobile devices from a list based upon available characteristics 115. As appreciated, additional or fewer characteristics may be included within characteristics 115 to specify performance of mobile device 114 without departing from the scope hereof.

As new mobile device types are created, additional mobile device characteristics 115 may be easily created to specify the performance of the new device types, allowing application development to start before a physical mobile device is available. For example, if a company introduces a new series of six mobile phone handsets, six additional mobile device characteristics 115 may be created based upon measured (e.g., by running benchmarks on the new handsets

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or prototype) or determined (e.g., by estimating performance based upon previous models) performance thereby allowing emulation and evaluation of applications targeting these new devices.

In one embodiment, mobile device characteristics **115** may be supplied with a device model specific to one mobile device. For example, a manufacturer may supply a combined device model and characteristics for each mobile device **114**. Emulator **101** may then utilize the combined device model as device model **102**.

In one example, computer **130** may include an interface (not shown) that provides communication with mobile device **114** via one or more of: USB, Ethernet, infra-red, Bluetooth, WiFi and other similar communication media. This interface may, for example, allow application **104** to be deployed on mobile device **114** for final testing of application **104**.

In one example of operation, processor **136** loads at least part of emulator **101** into memory **132** for execution. Emulator **101** then generates mobile device model **102**, based upon characteristics **115**, within memory **132**. Emulator **101** then loads and plays application **104** within model **102**. Emulator **101** may load all or part of profiler **106** into memory **132** to monitor resources and/or performance of application **104** within model **102**. Specifically, as application **104** is played (i.e., utilizing a Flash Player **154**) within model **102**, profiler **106** monitors and records, as profiled data **152**, resources utilized by application **104**. Profiled data **152** may be stored (as shown in dashed outline) within storage **134** and/or displayed as frame based profile data **110** on display **140** of terminal **138**. In particular, frame based profile data **110** may be used to identify areas within application **104** where upon playing of application **104** within mobile device **114**, performance of mobile device **114** would be stressed. Thus, areas where failure may occur within application **104** may be identified prior to running application **104** on mobile device **114**. For example, emulator **101** may display all or part of profile data **152** on display **140** to facilitate development of application **104**.

FIG. 2 is a block diagram illustrating emulator **101** of FIGS. 1A and 1B in further detail. In particular, profiler **106**, within emulator **101**, is shown with a processor profile module **202**, a memory profile module **204**, a graphic profile module **206** and a system profile module **208**. Processor profile module **202** may, for example, estimate processor utilization of application **104** within model **102**. Memory profile module **204** may, for example, estimate memory utilization by application **104** within model **102**. Graphic profile module **206** may, for example, estimate utilization of 3D fill rate and 3D polygon count of application **104** within model **102**. System profile module **208** may, for example, determine overall system utilization of application **104** within model **102**. More or fewer profile modules may be included within profiler **106** without departing from the scope hereof.

Device model **102**, within emulator **101**, has a modeled display **210**, a modeled processor **212**, modeled input keys **214**, modeled memory **216** and modeled non-volatile storage **218**. In this example, modeled display **210** represents display **118** of mobile device **114**, FIG. 1, processor **212** represents a processor (not shown) of mobile device **114**, modeled input keys **214** represent input keys **120** of mobile device **114**, modeled memory **216** represents memory (e.g., RAM) of mobile device **114** and modeled non-volatile storage **218** represents non-volatile storage (e.g., flash memory, disk drive storage) of mobile device **114**. Fewer or

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more elements and/or components of mobile device **114** may be modeled within device model **102** without departing from the scope hereof.

Modeled non-volatile storage **218** is shown with Flash Player **154** that may be the same as, or similar to, Flash Player **116**, FIG. 1. In one example, Flash Player **154** has similar operation to Flash Player **116**, but includes modifications that facilitate monitoring of application **104** within model **102** by profiler **106**.

Flash applications are based upon a timeline of frames that may include graphical information and action scripts, FS Commands, network protocols, selected frame rate, etc. Flash Player **116** within mobile device **114** thus operates upon a time line of frames within application **104** to provide graphical displays (e.g., animations, rich media content) upon display **118**. Accordingly, profiled data **152** may also be based upon the timeline and frames of application **104** and displayed (e.g., frame based profile data **110**) as resource utilization related to one or more of: timeline, frames and processing performance of action scripts.

In FIG. 2, application **104** is shown with a timeline **222** that includes frames **223**. Each frame of frames **223** may include graphics and/or action scripts that generate the graphical image for display. For example, an action script may reference one or more graphic files (e.g., movie file **224**) to provide graphical images for display **111**. Where each frame of frames **223** includes multiple graphic elements and/or action scripts that involve image manipulation (e.g., retrieving data from non-volatile storage, Avatar manipulations, animations, etc.), each frame may require differing resources in order to display correctly. For example, where a frame includes Avatar (e.g., an animated character) manipulation, a certain amount of processor resource is required, whereas a frame that is based upon movie file **224** may simply require data transfer time. If mobile device **114** has insufficient processor resources (e.g., because the animation is too complex for the targeted mobile device), application **104** may crash (i.e., cease to function correctly). Thus, it is important to determine the ‘stress’ applied by application **104** to resources of mobile device **114**.

In one example of operation, Flash Player **154** plays application **104** within model **102**. In particular, player **154** processes frames **223** of application **104** based upon ordering of timeline **222**. One or more profiler modules **202**, **204**, **206** and **208** within profiler **106** monitor resource utilization of each frame, storing results as profiled data **152**. Profiled data **152** is then displayed as frame based profile data **110** on display **140** for review by the user. Profile data **152** may be displayed in real time as application **104** is played within model **102**. Alternatively, the user may scroll through profile data **152** as desired by interacting with data display **110**. Alternatively, profile data **152** may be output as a report (not shown). The user interacts with emulated mobile device display **111** to control application **104** as if application were running on device **114**.

FIG. 3 shows one exemplary display **300** showing a frame based display of profiled data **152**, FIG. 1A, determined by processor profile module **202**. In particular, display **300** is shown with a time line **302** that represents timeline **222** of application **104**. In this example, each bar **304** indicates processor resource utilization for certain frames **223** of application **104**. During play of application **104** within model **102**, a current position indicator **306** shows the frame (i.e., frame **1** in this example) currently displayed by emulated mobile device display **111** (see FIG. 4). A capacity line **308** (capout) indicates the maximum processor resource

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available to application 128. Where bars 304 rise above capacity line 308 at locations 310, resource utilization for indicated frames of application 104 exceed the available processor resources of mobile device 114; thus application 104 may ‘capout’ or crash when playing those frames. Display 300 clearly displays processor resource utilization by frame 223 of application 104, thereby facilitating assimilation of stresses applied to mobile device 114 when playing application 104.

Other profile modules 204, 206 and 208, may have similar displays that clearly indicate resource utilization during playing of application 104 within model 102, thereby estimating resource utilization of application 104 when played within mobile device 114.

FIG. 4 shows one exemplary display 400 generated from device model 132 within emulator 120, FIG. 1. In particular, display 400 shows an image (e.g., generated from a bitmap of mobile device 114) of mobile device 114 with a display area 402 and input keys 404. Display 400 allows the user to see and interact with an application running within device model 132. For example, display area 402 may represent display 118 of mobile device 114 and input keys 404 may represent input keys 120 of mobile device 114.

FIG. 5 shows one exemplary window 500 that includes display 300 of FIG. 3 and display 400 of FIG. 4 and an exemplary user interface. In particular, window 500 shows selection of a mobile device (i.e., NOKIA 3650 in this example) from a pull-down list 502 that results in display of characteristics 504 of the selected mobile device. Characteristics 504 may represent characteristics 115 of FIG. 1A, for example. Window 500 facilitates interaction with model 102 through display 400 and monitoring of resource utilization of application 104 through window 300. Further, pull-down list 502 allows easy selection of further mobile devices upon which application 104 is to be profiled.

FIG. 6 is a flowchart illustrating a method 600 for modeling and profiling an application playing on a mobile device that includes a Flash Player. Method 600 may, for example, be implemented within emulator 101.

In step 602, method 600 loads characteristics defining performance of the mobile device. In one example of step 602, a user of window 500 selects a mobile device using pull-down list 502 and emulator 101 loads mobile device characteristics 115 into memory 132.

In step 604, method 600 emulates the mobile device using a model based upon the characteristics. In one example of step 604, emulator 101 generates device model 102 based upon mobile device characteristics 115.

In step 606, method 600 loads the application into the model. In one example of step 606, emulator 101 loads application 104 into device model 102.

In step 608, method 600 plays the application within the model. In one example of step 608, emulator 101 plays application 104 within model 102.

In step 610, method 600 monitors the application playing in the model to determine resource utilization of the application for the mobile device. In one example of step 610, emulator 101 utilized profiler 106 to monitor application 104 playing within model 102 to determine profiled data 152.

In step 612, method 600 displays the resource utilization information. In one example of step 612, emulator 101 displays all or part of profiled data 152 as frame based profile data 110 on display 140.

FIG. 7 is a flowchart illustrating one method 700 for authoring, emulating and profiling an application to play on a mobile device that includes a Flash Player. Method 700 may be implemented within emulator 101, for example.

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In step 702, method 700 authors an application for a mobile device. In one example of step 702, a user interacts with frame based application development tool 112 to author application 104.

In step 704, method 700 plays the application within an emulation of the mobile device. In one example of step 704, emulator 101 generates model 102 based upon characteristics 115 of mobile device 114 and then loads and plays application 104 within model 102.

In step 706, method 700 determines resource utilization of the playing application. In one example of step 706, emulator 101 utilizes one or more profile modules 202, 204, 206 and 208 of profiler 106 to determine resource utilization of application 104 within model 102 and stores the resource utilization information as profiled data 152.

In step 708, method 700 evaluates resource utilization in view of characteristics of the mobile device. In one example of step 708, emulator 101 evaluates profiled data 152 to determine, based upon characteristics 115, if resource utilization is within available resources of mobile device 114.

Step 710 is a decision. If in step 710, method 700 determines that the resource utilization of step 708 is within available resources of mobile device 114 (i.e., OK), method 700 continues with step 714; otherwise method 700 continues with step 712.

In step 712, method 700 authors the application to resolve resource issues. In one example of step 712, the user modifies application 104, based upon determined resource utilization of step 708, using development tool 112. Method 700 continues with step 704. Steps 704 through 712 thus repeat until the estimated resources requirement of the application is within available resources of the mobile device.

Step 714 is optional and is particularly suited for testing applications (e.g., application 104) running on a mobile device (e.g., mobile device 114) that is a mobile phone. In step 714, emulator 101 interacts with one or more operator development servers (e.g., operator development server 808, FIG. 8) to configure device model 102 for simulated network operation to allow testing of application 104 within a simulated wireless network environment (e.g., a simulated mobile phone wireless network environment). Simulated network operation is described in further detail below and shown in FIGS. 8 through 13.

In step 716, method 700 transfers the application to the mobile device. In one example of step 716, emulator 101 instructs development tool 112 to publish application 104 to mobile device 114.

FIG. 8 is a block diagram illustrating interaction of emulator 101 with an operator development server 808 via Internet 822 for simulating playing of application 104 within a mobile device connected to a wireless network (e.g., a mobile phone wireless network). FIGS. 9, 10, 11 and 12 show exemplary windows that allow a user to interact with emulator 101 for configuring and testing operation of application 104 within model 102 when simulating connection to a wireless network. FIGS. 8, 9, 10, 11 and 12 are best viewed together with the following description.

Emulator 101 is shown with an operator interface 802 that interacts with operator development server 808 via Internet 822. Internet 822 may, for example, represent the world wide web (WWW), an Intranet or any fixed or wireless server connection. Operator development server 808 is shown with a simulator 810, characteristic data 815 and model data 820. Model data 820 may, for example, represent live network profiles. To facilitate connection to operator development server 808, a user of emulator 101 purchases a

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subscription from a provider of operator development server **808** (or from a third party) that allows emulator **101** to connect to operator development server **808** via Internet **822**. Upon connection to operator development server **808**, emulator **101** may download characteristic data **815** from operator development server **808** for one or more mobile device types supported by operator development server **808** (i.e., supported by the operator's wireless network). Characteristic data **815** may, for example, represent mobile device characteristics **115** of FIG. 1. Further, emulator **101** may download additional model data **820** for use within device model **102** for increasing simulated functionality of model **102** (e.g., simulating additional handset functionality and/or network functionality). The user of emulator **101** may, for example, purchase data **820** for additional mobile device types as they become available, thereby allowing emulator **101** to include modeling capability for a new pre-release mobile device, scheduled release mobile device and current mobile devices. Alternatively, the use of data **815** and data **820** may be included within a monthly subscription fee, thereby allowing the user to author applications for new mobile devices (e.g., new mobile phone models and live mobile profiles) provided by an operator (e.g., mobile phone wireless network operator).

In one example of operation, emulator **101** downloads a network simulator interface **804** from operator development server **808** into device model **102** as shown in FIG. 8. Network simulator interface **804** includes functionality that allows device model **102** to communicate with simulator **810** to simulate connectivity of mobile device **114** with a wireless network. Specifically, network simulator interface **804** within model **102** interacts with data provider **812** and event generator **814** to determine resource utilization resulting from network interaction by model **102**. Thus, as application **104** plays within model **102**, the effects of device **114** interacting with a wireless network are simulated such that frame based profile data display **110** shows resource utilization that includes the live or scripted effects of interaction with the wireless network. In one embodiment, capacity line **308** of display **300** within profile data display **110** is dynamically modified to show actual resource availability to application **104** resulting from resource utilization by simulated wireless network activity within device model **102**. For example, if a message is received and/or retrieved by model **102** while playing application **104**, certain resources are required to handle the received message, and therefore available resources for application **104** is reduced accordingly.

Simulator **810** is shown with a data provider **812** and an event generator **814**. Data provider **812** may, for example, simulate data transfers within a wireless network. For example, the data transfer may be based upon a certain bandwidth associated with the wireless network. Event generator **814** may, for example, generate certain events (e.g., incoming calls, incoming text messages, etc) that occur within a wireless network. Simulator **810**, using data provider **812** and event generator **814**, thus interacts with network simulator interface **804** to model operation of a wireless network (e.g., a mobile phone network).

Operator interface **802** may interact with multiple operator development servers **808** to facilitate testing of application **104** with many operators' networks. As appreciated, where application **104** is designed to function on multiple mobile devices operating on wireless networks worldwide, operator network simulation removes the burden of traveling to operator network locations from application developers, since application operation on a mobile device connected to

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a network may be simulated by emulator **101** and thus measured back against the authoring environment.

FIG. 9 shows one exemplary window **900** for selecting operator networks based upon geographic location. Window **900** shows a menu item **902** that, upon selection by the user, displays a world map **904** that allows the user to select a geographical region in which mobile device **114** is to operate. For example, window **900** shows a mouse pointer **906** selecting the United Kingdom, resulting in a sub-map display **908** of the selected location showing available wireless networks **910**. Sub-map display **908** is, for example a 'mouse-over' event. Upon selection of the location, world map **904** is replaced by sub-map **908** of the selected location and a pull-down list **1004** of available operators within that location as shown in window **1000**, FIG. 10. Alternatively, the user may select menu item **1002** to display pull-down list **1004**.

Upon selection of an operator within list **1004**, emulator **101** displays a pull-down list **1104** of mobile devices supported by the selected operator, as shown in window **1100** of FIG. 10. Alternatively, the user may select the menu item **1102** to display list **1104**. Upon selection of a mobile device from list **1104**, window **1200**, FIG. 12, is displayed to allow the user to select desired network characteristics for simulation.

Window **1200** shows a pull-down list **1202** of network characteristics that may be simulated by simulator **810**. For example, simulator **810** may allow control of scripted events (e.g., cell tower identification, service message, bandwidth, etc.), consumer events (e.g., checking email, checking messages, browsing network, available minutes, selecting images, etc.) and incoming events (e.g., phone calls, WAP Messages, receiving MMS, receiving SMS, etc.). Based upon selection from list **1202**, a second list may be presented to allow further simulation requirements to be entered. In the example of window **1200**, consumer events entry of list **1202** was selected, resulting in display of pull-down list **1204** from which check messages was selected resulting in the display of pull-down list **1206**. In this example, the user may select 'send message' from list **1206** to evaluate the performance of application **104** while a message is received from the network.

In one embodiment, maps **904**, **908** and lists **1004**, **1104**, **1202**, **1204** and **1206** are based upon information received by operator interface **802** from one or more operator development servers **808**. Thus, functionality of model **102** and selectable simulations of simulator **810** may be easily updated by the operator as new mobile devices are created without requiring updates to software of emulator **101**.

Optionally, the user may select menu item **901**, FIG. 9, to immediately locate, download and import modeling characteristics into emulator **101**. These characteristics may be stored within storage **134** of computer **130**, FIG. 1B.

FIG. 13 is a flowchart illustrating one exemplary method **1300** for configuring wireless network simulation.

In step **1302**, method **1300** selects a geographic location of the wireless network. In one example of step **1302**, emulator **101** displays window **900** and the user selects the United Kingdom as the wireless network location.

In step **1304**, method **1300** selects a network operator from within the selected location. In one example of step **1304**, emulator **101** displays window **1000** including pull-down list **1004** of network operators within the location selected in step **1302**.

In step **1306**, method **1300** connects to the selected network operator's development server. In one example of step **1306**, emulator **101** utilizes operator interface **802** to

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connect to operator development server **808** based upon the operator selected in step **1304**.

In step **1308**, method **1300** downloads a list of mobile devices supported by the simulator of the operator selected in step **1304**. In one example of step **1308**, emulator **101** downloads characteristic data **815** from server **808** to determine mobile devices supported by simulator **810** and populates list **1104** of window **1100**. Of note, an operator may add functionality to simulator **810** based upon a new mobile device prior to supporting the device within the operator's wireless network, thereby encouraging development of applications for the new device before its launch, increasing operator and/or author revenues.

In step **1310**, method **1300** selects a mobile device from the list of supported mobile devices. In one example of step **1310**, the user selects a mobile device for emulation from list **1104** of window **1100**. In another example, where the user has already selected a mobile device from pull-down list **502**, emulator **101** automatically selects the same device, if available, from list **1104**.

In step **1312**, method **1300** downloads a network simulator interface for the selected mobile device. In one example of step **1312**, emulator **101** instructs operator interface **802** to download network simulator interface **804** from server **808**.

In step **1314**, method **1300** loads the network simulator interface into the mobile device model. In one example of step **1314**, emulator **101** loads network simulator interface **804** into model **102**.

In step **1316**, method **1300** selects network characteristics to simulate. In one example of step **1316**, the user utilizes lists **1202**, **1204** and **1206** of window **1200** to specify network characteristics for simulation by simulator **810**.

In step **1318**, method **1300** models the application running within a mobile device connected to a wireless network. In one example of step **1318**, model **102** interacts with simulator **110** via network simulator interface **804** and internet **822** while playing application **104** and displaying profile data display **110**.

In one embodiment, the user may purchase and download simulator **810** from operator development server **808** to facilitate local simulation of the wireless network (i.e., without utilizing Internet **822**). In this embodiment, simulator **810** may operate within emulator **101**, within authoring environment **122** or within computer **130** to provide interaction with model **102**.

Emulator **101** may utilize operator interface **802** to interact with one or more operator development servers **808** to download characteristics (e.g., characteristic data **815**) and modeling data (e.g., model data **820**) for generating mobile device model **102**. As new mobile devices are made available, each application author (i.e., user) is able to download these modeling characteristics and test applications for the new mobile device. As mobile devices become more sophisticated and include additional hardware and functionality, emulator **101**, through a subscription service with an operator, for example, may download this additional functionality for use in model **102**. These characteristics (e.g., characteristic data **815**) may include bitmaps, characteristics handset profiles, modeling algorithms, complete mobile device models, bandwidths etc. thereby automatically updating functionality of authoring environment **122**. Wireless network operators participate by updating their development servers (e.g., development servers **808**) to provide the latest emulation information and functionality for each supported mobile device (e.g., mobile phone handset) and by updating

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their network simulators (e.g., simulator **810**) to include functionality and/or proposed functionality of their wireless networks.

Application authors (e.g., users of emulator **101**) are provided with a visual authoring environment in which the authored application may be emulated as operating within one or more modeled mobile devices (that are optionally connected to a simulated wireless network) without leaving the authoring environment.

The emulator (e.g., emulator **101**) may be provided as part of the authoring environment, or as an add-on to an existing development tool. In an embodiment, characteristics for each mobile device to be emulated are downloaded from a server for a determined price or subscription fee. Since new mobile devices are continually being produced, application authors continually require new modeling characteristics to be able to test their applications. For example, a subscribed charge of \$10-15 dollars per handset saves each developer from purchasing a mobile device (\$100-200 dollars) and alleviates the need to travel to a wireless network location when testing each mobile device. Thus, the wireless network operator may receive revenue from developers by providing the developers with online network simulation capability.

The application authors, via the Internet, are then able to test applications for mobile devices running on wireless networks worldwide.

Characteristics for each mobile device to be emulated may be downloaded from a server for a determined price, licensing or subscription fee. It is estimated that nearly 700 million new mobile devices will be shipped in 2005, with a new handset model being launched every other day. This rapid mobile device development requires that applications designed to run on these mobile devices also sustain rapid development. Development systems targeted at one mobile device may become obsolete and possibly of little value to the developer at the time it is shipped. Since a new mobile device is being launched every other day, application authors continually require purchasing all addressable targeted devices prior to consumer release. For example, a charge of \$10-15 dollars per modeled handset would save each developer purchasing each target mobile device (\$100-200 dollars) as well as alleviating the need to travel to a wireless network location whilst testing each mobile device before public release, two substantial development and release costs.

During development of an application for a mobile device, an application author may transfer and play the application hundreds of times (development life cycles) on the targeted mobile device before identifying and correcting all system resource problems within the application. Live server and profile updates would substantially reduce and alleviate a high churn rate of development life cycles, enabling a more cost effective authoring model for the developer. As well, although the purchase of a 'static' PC authoring environment may become obsolete due to the ongoing release of new mobile handsets (the target release platform) emulator **101** and operator development server **808** maintains a live and continually updatable business model and authoring platform long after the initial authoring platform has released to the market.

FIG. 14 is a flowchart illustrating one method for determining whether an application of a mobile device is operable. In step **1402**, method **1400** downloads characteristics over Internet for one or more mobile devices to be emulated. In step **1404**, method **1400** tests the application for the

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mobile devices, via the Internet, using an emulator to determine if the application is operable on the mobile device.

Changes may be made in the above methods and systems without departing from the scope hereof. It should thus be noted that the matter contained in the above description or shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense. The following claims are intended to cover all generic and specific features described herein, as well as all statements of the scope of the present method and system, which, as a matter of language, might be said to fall there between.

What is claimed is:

1. A non-transitory, computer-readable medium comprising software instructions for developing an application to be run on a mobile device, wherein the software instructions, when executed, cause a computer to:

display a list of a plurality of mobile device models from which a user can select, wherein each model includes one or more characteristics indicative of a corresponding mobile device;

simulate at least one of the one or more characteristics indicative of the mobile device corresponding to the selected mobile device model;

simulate one or more characteristics indicative of a network on which the mobile device corresponding to the selected mobile device model can operate;

monitor utilization of a plurality of resources over time as the application is running;

display simultaneously two or more graphical images of the application's resource utilization, wherein each graphical image relates to a different resource;

correspond the utilization of a specific displayed resource at a given time with one or more functions of the application responsible for that utilization.

2. The medium of claim 1, wherein the instructions initiate transmission of the application that is being developed to one or more physical versions of a mobile device corresponding to the selected mobile device model.

3. The medium of claim 2, wherein the instructions initiate downloading of at least one of the one or more simulated characteristics from a remote server.

4. The medium of claim 2, wherein the one or more characteristics indicative of the mobile device corresponding to the selected mobile device model include at least one of processor type, processor speed, storage access speed, RAM size, storage size, display width, display height, pixel depth, processor availability, RAM availability or storage availability.

5. The medium of claim 4, wherein the monitored resources include processor usage, RAM usage and network usage.

6. The medium of claim 5, wherein the one or more characteristics indicative of a network are derived at least in part from information captured from one or more wireless networks.

7. The medium of claim 5, wherein the one or more characteristics indicative of a network are based on a geographical region.

8. The medium of claim 5, wherein the instructions simulate one or more network events that occur when interacting with a wireless network.

9. A non-transitory, computer-readable medium comprising software instructions for developing an application to be run on a mobile device, wherein the software instructions, when executed, cause a computer to:

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display a list of a plurality of mobile devices from which a user can target a particular device; model one or more characteristics indicative of the targeted mobile device;

monitor utilization of a plurality of resources over time as the application is running;

display simultaneously two or more graphical images of the application's resource utilization as it is running, wherein each graphical image relates to a different resource and is synched in time as the application is running;

identify one or more functions of the application responsible for utilization of a specific displayed resource at a given time.

10. The medium of claim 9, wherein the instructions initiate transmission of the application that is being developed to one or more physical versions of a mobile device corresponding to the targeted mobile device, and initiate downloading of at least one of the one or more modeled characteristics from a remote server.

11. The medium of claim 10, wherein the one or more characteristics indicative of the targeted mobile device include at least one of processor type, processor speed, storage access speed, RAM size, storage size, display width, display height, pixel depth, processor availability, RAM availability or storage availability, wherein the monitored resources include at least one of processor usage, RAM usage and network usage.

12. The medium of claim 10, wherein the instructions simulate one or more characteristics, including bandwidth, indicative of a network on which the targeted mobile device can operate.

13. The medium of claim 12, wherein the one or more characteristics indicative of a network are derived at least in part from information captured from one or more wireless networks.

14. The medium of claim 12, wherein the instructions simulate one or more network events that occur when interacting with a wireless network, wherein a user can create scripts to emulate actions of real user behavior to determine the performance of the application, or the network, or both.

15. A non-transitory, computer-readable medium comprising software instructions for developing an application to be run on a mobile device, wherein the software instructions, when executed, cause a computer to:

display a list of a plurality of mobile device types from which a user can select;

simulate one or more characteristics indicative of the selected mobile device type;

initiate downloading of at least one of the one or more characteristics indicative of the selected mobile device type from a remote server;

monitor utilization of a plurality of resources over time as the application is running;

display one or more graphical images of the application's resource utilization as it is running;

identify one or more areas of code of the application responsible for utilization of a specific displayed resource at a given time.

16. The medium of claim 15, wherein the one or more characteristics indicative of the selected mobile device type include at least one of processor type, processor speed, storage access speed, RAM size, storage size, display width, display height, pixel depth, processor availability, RAM

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availability or storage availability, wherein the monitored resources include at least one of processor usage and RAM usage.

17. The medium of claim 16, wherein the instructions initiate transmission of the application that is being developed to one or more physical versions of a mobile device corresponding to the selected mobile device type.

18. The medium of claim 17, wherein the instructions display simultaneously two or more graphical images of the application's resource utilization as it is running, wherein each graphical image relates to a different resource.

19. The medium of claim 16, wherein the instructions simulate one or more characteristics, including bandwidth, indicative of a network on which the selected mobile device type can operate.

20. The medium of claim 19, wherein the one or more characteristics indicative of a network are derived at least in part from information captured from one or more wireless networks.

21. The medium of claim 19, wherein the one or more characteristics indicative of a network are based on a geographical region.

22. A non-transitory, computer-readable medium comprising software instructions for developing an application to be run on a mobile device, wherein the software instructions, when executed, cause a computer to:

simulate one or more characteristics indicative of the mobile device, wherein the one or more characteristics indicative of the mobile device include at least one of processor type, processor speed, storage access speed, RAM size, storage size, display width, display height, pixel depth, processor availability, RAM availability or storage availability;

monitor utilization of a plurality of resources over time as the application is running, wherein the monitored resources include at least one of processor usage and RAM usage;

display one or more graphical images of the application's resource utilization;

correspond the utilization of a specific displayed resource at a given time with one or more functions of the application responsible for that utilization;

initiate transmission of the application that is being developed to one or more physical versions of the mobile device.

23. The medium of claim 22, wherein the instructions initiate downloading of at least one of the one or more characteristics indicative of the mobile device from a remote server, wherein the one or more physical versions of the mobile device are connected to at least one of the internet,

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a wireless network and the remote server, to enable a user to interact with and test the application on one or more physical versions of the mobile device corresponding to a selected mobile device.

24. The medium of claim 22, wherein the instructions simulate one or more characteristics, including bandwidth, indicative of a network on which the mobile device can operate.

25. The medium of claim 24, wherein the one or more characteristics indicative of a network are derived at least in part from information captured from one or more wireless networks, wherein the information captured from one or more wireless networks are stored in at least one of a file, a database, and on computer-readable media that is accessible via the internet.

26. The medium of claim 24, wherein the instructions simulate one or more network events that occur when interacting with a wireless network, wherein a user can create scripts to emulate actions of real user behavior to determine the performance of the application, or the network, or both.

27. The medium of claim 24, wherein the one or more characteristics indicative of a network are based on a geographical region, wherein the network characteristics are displayed using at least one of a map, drop-down list, and drop-down menu to enable a user to at least select the network characteristics, manage the network characteristics, and create custom network characteristics to at least one of test how well the application performs on the network and the mobile device.

28. The medium of claim 24, wherein the instructions display simultaneously two or more graphical images of the application's resource utilization, wherein each graphical representation relates to a different resource and is synched in time as the application is running, wherein the instructions to display the graphical images are stored at least in a file, a database and on computer-readable media that is accessible via the internet.

29. The medium of claim 24, wherein at least one of the one or more network characteristics and the one or more mobile devices characteristics are stored on at least one of a file, a database and on a computer-readable media that is accessible via the internet.

30. The medium of claim 22, wherein the instructions include receiving a set of declared resources for the application, wherein the declared resources include information to evaluate performance of at least one of the application or a network.

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